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Atmospheric Measurement Techniques Discussions

Interactive comment on "Post-processing to remove residual clouds from aerosol optical depth retrieved using the Advanced Along Track Scanning Radiometer" *by* Larisa Sogacheva et al.

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Dear Referee #3,

Thank you very much for the attention to our manuscript. We considered your comments and made a lot of changes to shorten the discussion before the CPP method description, as you recommended. Discussion on cloud screening has been taken out from the manuscript. We emphasized the focus of the manuscript on the AOD post-processing, related to possible cloud contamination in the retrieved AOD. We implemented your specific corrections, which helped to improve the manuscript.

Interactive comment on "Post-processing to remove residual clouds from aerosol opti-

cal depth retrieved using the Advanced Along Track Scanning Radiometer" by Larisa Sogacheva et al. Anonymous Referee #3 Received and published: 12 October 2016

The paper describes an improved post-processing method for the removal of residual clouds in aerosol retrievals using AATSR observations. The previous version of this technique has already been published by Kolmonen et al. (2015). The authors compare both versions by means of case study examples as well as discussing the AOD results w.r.t. seasonal and temporal changes. From my point of view the paper is unnecessarily expanded, because the focus of this work is the presentation of the updated cloud post-processing scheme. The original scheme has already been published by Kolmonen et al. (2015). The authors failed at focussing on the description of the main improvements and associated changes in the aerosol retrieval results. The reader has to make a considerable effort to read through a lot of text until the point is reached, where the new work is being presented.

Ans: Following the Referee #2 and #3 recommendations, the paper has been shortened. The focus on the AOD post-processing has been emphasized. The discussion on cloud screening approaches has been taken away, since the post-processing introduced is applied to the AOD distribution retrieved and may be recommended in AOD retrievals as additional to cloud screening. We re-wrote the introductions and revised other sections according the Referee comments. We also combined sections 2, 3 and 4; 6,7 and 8. Figures 11 and 14 have been deleted.

I recommend accepting the paper with major revision required. I expect that the authors perform a re-writing of the paper leading to a clear and focused manuscript.

In the re-writing, they should take into account:

Introduction:

The introduction is not very strong and does not arouse interest encouraging the reader to read to the very end of the work due to dispensable information and lack of the

central theme. As a reader I would expect a clear structured introduction explaining the motivation, the state-of-the-art including challenges and the relevance of this work. In my opinion this introduction does not capture that.

Ans: We re-wrote the abstract and introduction to emphasize the focus of the manuscript on AOD post-processing to recognise the cloud-contaminated pixels.

P2L2: "Usually the retrieval is only made for cloud-free scenes, . . ." Is there any aerosol retrieval that is capable to retrieve AOD in the presence of clouds? I would suggest removing the word "Usually" since the second part of that sentence contains ". . ., which implies that a very strict cloud detection scheme has to be applied to remove all cloudy pixels from the retrieval area." This means a clear-sky conservative cloud screening is required for aerosol retrieval, which per se means cloud-free.

Ans:The discussion on cloud screening approaches has been taken away. See the reply to General comments.

P2L18-26: The authors describe the general cloud screening approach, i.e. how clouds are characterized when looking from space. However, they do not mention the limitations, such as, bright clouds over desert and snow/ice covered areas, cold clouds over cold surfaces, extreme case: low clouds that are warmer than the surface.

Ans:The discussion on cloud screening approaches has been taken away. See the reply to General comments.Short discussion on the cloud misclassification is added to the introduction

The description of ideal satellite sensors for the retrieval of aerosol and clouds are not relevant for this paper, thus, should be deleted.

Ans:Deleted

I would suggest writing a concise paragraph about cloud detection methods and their limitations with regard to spectral imagers, such as AATSR, referencing appropriate literature. Difference and threshold approaches are not the only methods that are

being used for cloud masking, such as learning algorithms (e.g. neural network).

Ans:The discussion on cloud screening approaches has been taken away. See the reply to General comments.

P2L27-P3L9: This paragraph is a mix of cloud tests being explained later in Section 4 (what is used in this work) and other techniques published by different groups. I would suggest writing a more general state-of-the-art summary of cloud detection methods rather than mixing it, because these cloud tests ("T1", "T2", etc.) are not relevant here, but the physics is. See previous comment P2L18-26.

Ans:Since the focus of the current manuscript was on the developing the cloud contamination post-processing method, but not on the evaluation of the existed cloud screening in ADV, we shortened the ADV cloud tests description and refer to Robles Gonzàlez (2003) and Kolmonen et al., (2015), where the ADV cloud tests are introduced and discussed. Short discussion on cloud misclassification in "complicated" environments (e.g., bright surfaces, small cumulus clouds, thin clouds over dark surfaces) is added to Introduction.

Section 2: P4L20: Change "and four in the mid- to thermal infrared" to "and four in the near- to thermal infrared".

Ans:changed

P5L2: Please explain in the text why the retrieval uses only 865 nm measurement over ocean?

Ans:The explanation is added in Sec.2

P5L12-14: Superfluous, thus should be deleted.

Ans:deleted

Section 4: Subsection 4.1 describing the cloud tests is difficult to read and tells only half of the story. I would suggest shortening the description using enumeration. Maybe

a sketch/scheme illustrating the tests could be useful for the reader. Is the order of the applied tests unimportant for the thresholding used here for cloud detection? There are other thresholding approaches, where the order of the tests is important for the pixel classification. This might be not the case for a clear-sky conservative approach, but please mention it here or explain it.

Ans:This section has been shortened and combined with the previous section

The authors make general statements, such as “clouds are cooler than ..” or “clouds are brighter than the underlying surface . . .”. However, there are cases where this might be not true and I wonder what the result would be in such cases inwewvwr this study? Are there any checks for the cloud tests applied?

Ans:For the global runs, we do not have any check on the cloud screening results. However, we participated in several exercises initiated in Aerosol_cci project and we conducted our own comparison on the performance on the each cloud test in ADV. Some problems have been recognised, which can be resolved on test-cases scale, but globally the current cloud screening gives better (compared to “tuned” for test cases) results. We are planning another manuscript, where we will introduce problems in ADV cloud screening and possible solutions in more details.

Since different threshold values over land and ocean are used, please mention which land/sea mask you are using. Is a DEM used?

Ans:For land/sea classification, we use the AATSR land/sea mask. We added this information to the manuscript.

What about sun glint or snow/ice and desert surfaces where clouds might be as bright as the underlying surface? What about sub-pixel clouds or cloud edges? Are they removed later by the CPP scheme?

Ans:We added the description on the glint and bright surface treatment to Sec.2

To summarize, cloud screening using spectral imager observations is not as simple as

it is pictured here. The authors are mentioning on page 3 (L5-8) difficulties w.r.t. cloud masking, however, since the focus of this paper is the cloud detection used in by work, as a reader I am more interested in understanding the capabilities and limitations of the presented cloud detection.

Ans:The main focus of the paper is on the AOD post-processing to remove the cloud contamination. Cloud tests are introduced as they exist in ADV (Kolmonen et al., 2016)

P6L25: Why is only the forward view used in ASV and cloud detection, i.e. over ocean? Why not the nadir view or forward+nadir views?

Ans:In ASV, the TOA reflectance from only one view (nadir or forward) is used in AOD retrieval. Thus, the cloud masking is done in the ASV for the view, which is used. Since the glint is recognized in nadir view more often, forward view is currently used in ASV (usage of only nadir is another option). However, the option for cloud screening for both views exists in ASV.

Is it really necessary to discuss here the cloud screening and subsequent AOD results excluding the CPP method? Since the focus is the improved CPP method, why not discussing cloud detection and AOD results in Section 5 along with retrieval, old and new CPP? From my point of view the paper would benefit from merging 4.2 and 4.3 subsections (shortened!) into Section 5.

Ans:“All pixels retrieved” is not the ADV/ASV product. In current manuscript, we aimed to introduce the CPP method in more details, than it is in Kolmonen et al. (2016) and show the progress in the developing of the CPP methods

Section 5: First of all, I agree with the second reviewer that the word “plume” should not be used in this context. Aerosol plumes are related to wildfire, volcanic, and desert dust events.

Ans:The word “plume” is replaced with “high-AOD”

P8L6: “Each pixel is analyzed together with eight surrounding pixels.” How are borders

treated, i.e. edges of an orbit?

Ans:The edges of an orbit are treated similarly. Since we do not know what are the cloud conditions outside the orbit, we prefer to be more strict to avoid cloud contamination.

Subsection 5.2 describing the improved CPP method and limitation is difficult to read and to understand. I had to read it several times because I am not familiar with that work. Figure 6 is also very difficult to understand, it is not well explained in the subsection and is not helping at all to understand the text. I do not understand why the authors have chosen N>3 and A<0.2 as criteria when looking at Figure 6. The authors should explain in the text as well as in the figure caption why they have selected this combination of criteria for ImCPP.

Ans:This paragraph is rewritten according to the Referee comments. In Figure caption, ee added the reference to the sections, where the choice for the thresholds is discussed.

In the lower panel of Fig. 6 (China) the blue dashed line for ExCPP is missing!

Ans:Validation for China AOD retrieved with the ExCPP is not possible. With the ExCPP, there were no ADV AOD pixels left collocated with the AERONET.

P9L18: ". . . for the Globe . . ." The authors are using terms such as "Globe", "globally" and "the whole world" throughout the paper. Thus, a reader assumes that no region is excluded from the analysis. When looking at Fig. 9 obviously desert areas and Polar Regions are excluded from the retrieval. However, the authors do not mention this fact.Aerosol retrievals over bright surfaces are challenging but not impossible. In section 3 describing the algorithms the authors should be more precise what they mean with "over land" and "over ocean", excluding desert, snow/ice and sea ice? How are such pixels excluded from the retrieval? Is it done in the pre- or post-processing?

Ans:Short description on the ADV capability to retrieve over bright surfaces is added to

Sec. 2.

P9L25: "By lack of independent validation data, visual inspection is the main instrument to judge the cloud screening results." I do not agree with this statement. Visual inspection is one method. Validation data is rare. However, there are other well-known reference data sets, which are used for inter-comparison studies and for evaluating the cloud screening results. For instance, CALIPSO, MODIS/Terra, ARM sites, SYNOP data, etc. CALIPSO is in the A-train constellation and collocated pixels will be found only at higher latitudes. MODIS/Terra has the same equator crossing time as ERS-2 (ATSR-2) and has a 30 minutes difference with ENVISAT (AATSR). Please note, MODIS/Terra collection 6 cloud products should be not used after 2010 because band 29 detector crosstalk degradation results in artificially high cloud cover over tropical oceans. Thus, please re-write this sentence, for instance: "Visual inspection has been chosen to evaluate the cloud screening results."

Ans:The sentence is re-written according the Referee suggestion.

P10L15-27: I am not sure if this subsection is really necessary because Fig. 3 and Fig. 4 are already demonstrating the aerosol retrieval, ExCPP and ImCPP results.Fig. 7 does not convey additional information. In my opinion, subsection 5.3 and Fig.7 could be deleted.

Ans:In Fig. 7 we show how the ImCPP works in different aerosol conditions. Thus, we find this figure 7 and correspondent text (P10L15-27) relevant to the manuscript.

Section 6: P11L14-17: The evaluation of the new results should be focused on the intercomparison between all retrievals vs. retrievals after ImCPP instead of focusing on old vs. new CPP results. This would highlight better the improvements, especially those for China. In the case of China the old CPP scheme removed too many pixels, while ImCPP provides more valid retrievals leading to a better correlation with AERONET. The scatter plots in Figure 8 demonstrate this very nicely. Thus, I would recommend swapping ExCPP and ImCPP columns and focusing on the improvements:

all retrieval vs. ImCPP.

Ans:“All pixels retrieved” is not the final, but the intermediate ADV/ASV product, although we perform the validation and check the AOD spatial distribution for that product. In current manuscript, we show the progress in the developing of the CPP method, thus ImCPP should be compared with the ExCPP.

Fig. 8: The magenta dots and lines are hardly visible. Only when displaying on the screen and zooming into the plot I can recognize the dots and lines. Thus, I would recommend re-plotting those scatter plots (and increase them a little bit). Maybe it is better to choose another color bar for the scatter so that the binned AOD mean and standard deviations can be plotted using a distinct color.

Ans:Color map has been changed to make the binned averaged AOD values more visible. 1:1 line is extended.

Section 7: Figure 11 is uninteresting since Figure 10 shows already the impact of ImCPP. Thus, this figure can be deleted.

Ans:Figure 10 shows the difference in AOD spatial distribution; Figure 11 shows how the area means have been changed. Following the Referee 3 suggestions, Fig.11 has been deleted.

Section 8: Figure 13: what is plotted in panel a, b, and c? Please specify it in the figure caption.

Ans:We specified in the figure caption, what is plotted in panels a and b.

The quality of the panels is insufficient. There are too many lines, regions and colors. It is pretty time-consuming and difficult to analyze and understand those panels. Combining 4 different seasons, multiple regions and two different results (old and new CPP) in one plot is too much! When reading the section 8 along with Figure 13 I am confused. P12L25: “China and India (Fig. 13b) . . .”, however there is neither China nor India in Fig. 13 b. Maybe the authors meant 13c? Why is the “Globe” plotted in each

panel? Overall, Figure 13 and section 8 are very difficult to follow. Thus, I recommend re-plotting Figure 13, i.e. one or two regions per panel.

Ans:We removed some of the areas from the Fig.12 (Fig.11 in the revised version) Global AOD is plotted for the comparison.

Figure 14 and associated paragraph should be deleted because there is no new information.

Ans:Figure 14 is deleted

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